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22510

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1182

BALLISTIC TESTS IN THE 5"/38 CALIBER BLOWOUT GUN

THE PRODUCTION OF PRESSURE WAVES IN THE 5"/38 CALIBER BLOWOUT GUN

2nd Partial Report

Task Assignment NPG-Re2d-02-1-53

Copy No. 10

Classification CONFIDENTIAL SECURITY INFORMATION

Ballistic Tests in the 5"/38 Caliber Blowout Gun

PART A

SYNOPSIS

1. This report covers a group of firings conducted in the 5"/38 Caliber Blowout Gun. The objects of the firings were to determine the possibility of producing pressure waves in the chamber of the Blowout Gun and to determine the degree to which breech pressure records from a standard 5"/38 caliber gun could be reproduced in the Blowout Gun.

a. Two series of rounds were fired in this test. The first series of firings were made to establish the conditions under which pressure waves could be produced in the Blowout Gun. The second series of firings were made to compare breech pressure curves obtained from the Blowout Gun with those obtained from a standard 5"/38 gun, with similar cartridge case loading conditions in both guns. Four different types of experimental primers and one standard primer were used in the latter firings.

b. Pressure-time curves were obtained on all rounds at the base of the case and at three positions along the chamber of the Blowout Gun. Included as enclosures to this report are reproductions of original oscillograms of pressure-time curves, breech pressure-time curves from the Blowout Gun and a standard 5"/38 gun using the same charge and primer and high speed photographs of primer venting.

2. On the basis of the results obtained on these tests, it is concluded that:

a. Pressure waves can be produced in the Blowout Gun. The wave configuration depends on the size of the vent in the gun and on the type of primer used.

b. The wave configuration obtained in a 5"/38 Caliber Gun can be duplicated closely in the Blowout Gun over a wide range from "smooth" to "very rough" pressure curves.

c. Burning of the propellant begins in the region of the first two vent holes in the primer, as determined from the pressure-time data and high-speed movies of primer venting.

d. For the series of primers used on these tests, the pressure waves become more pronounced as the point of ignition is moved forward in the charge (as the length of the unvented portion of the primer tube is increased).

e. The velocity of the burning front in the charge is directly proportional to the weight of the black powder used in the primer tube and varied from 900 f/s to 1300 f/s for the primers used in this test.

Ballistic Tests in the 5"/38 Caliber Blowout Gun

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Ballistic Tests in the 5"/38 Caliber Blowout Gun

PART B

INTRODUCTION

1. AUTHORITY:

The tests reported were conducted under Task Assignment NPG-Re2d-02-1-53 as established by reference (a) and cover portions of the proposed program submitted by the Naval Proving Ground to the Bureau of Ordnance in reference (b).

2. REFERENCES:

a. BUORD Conf ltr NP9-Re2d-CNB:aph Ser 44690 of 12 Sep 1952
b. NAVPROV ltr OMI:MLF:msr A11/2d2-1 Ser 24209 of 11 Dec 1952
c. NPG Report No. 829 - "Construction and Calibration of a 5"/38 Blowout Gun"
d. NPG Report No. 940 - "Ballistic Test of Experimental Propellants in the 5"/38 Caliber Blowout Gun"
e. NPG Report No. 1033 - "Development of an Ignition System for the 5"/38 Caliber Gun" and "Tests in Connection with Primer Research and Development"

3. BACKGROUND:

The 5"/38 Caliber Blowout Gun was designed, constructed and instrumented for use in investigations of ignition and early burning characteristics of experimental and production propellants.

The construction of the gun was described in reference (c) and the results of preliminary exploratory firings were reported in reference (d). In reference (b) the Naval Proving Ground proposed a research program consisting of the following:

Phase A: To determine the conditions which will produce pressure waves in the Blowout Gun, similar to the pressure waves produced in a standard 5"/38 gun, when similar charges are fired in both guns.

Phase B: Propellant ignition research and development.

Phase C: Propellant research and development.

Ballistic Tests in the 5"/38 Caliber Blowout Gun

Phase D: Correlation between firings in the blowout gun and a regular 5"/38 weapon.

Although the tests reported here were conducted primarily to determine the possibility of producing waves in the Blowout Gun, as proposed under phase A, they have also yielded data relevant to phases B and D.

4. OBJECT OF TEST:

The primary objectives of the tests covered in this report were:

a. To determine the possibility of producing pressure waves in the Blowout Gun.

b. To correlate firings in the Blowout Gun with 5"/38 gun firings in which the only variable was the type of primer used.

A secondary objective, which arose upon preliminary analysis of results, was to determine what information relative to ignition could be derived from the pressure-time records.

5. PERIOD OF TEST:

a. Date Firing Began 2 Feb 1953

b. Date Firing Completed 27 May 1953

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

a. 5"/38 Blowout Gun:

Essentially the Blowout Gun consists of the breech section of a 5"/38 gun barrel cut off approximately 15" in front of the chamber. The forward or muzzle end of the Blowout Gun is modified to hold a rupture (blowout) disc at the position of projectile seating in a normal gun. The breech end consists of a breech cap fitted for firing an electric primer. The Blowout Gun chamber is drilled to allow for the insertion of three dynamic pressure gages at 3", 14" and 25" from the breech respectively. More complete details regarding the design of the Blowout Gun will be found in reference (c).

b. Charge:

The charge used in these tests was 15.53 lbs of NPFB-234 at 90°F. The powder, charge weight and loading is the same as that used in a standard 5"/38 gun.

c. Primer:

The primers used in these tests were XCM-11, XCDB 15/300, XCDB 75/400, XCDB 24/500 and XCDB 30/400. The design and loading characteristics of these primers will be found in Table I, Appendix (A), of this report. The XCM-11 primer is identical to the Mk 46 standard primer.

7. DESCRIPTION OF TEST EQUIPMENT:

A new set of pressure gages, incorporating improvements over the original gages designed for the gun, were constructed during the initial firings of the test.

The dynamic pressure gage consists of a short pressure sensitive ferrule with a 500 ohm strain gage attached circumferentially for the sensing element. The oscilloscopes have built-in D. C. amplifiers which have a frequency response from 0-50,000 c.p.s. ±0.5 decibel and have a gain of 25,000. The drum camera has a continuously adjustable speed from 5-1800 rpm.

8. PROCEDURE:

The first series of rounds were fired to determine the dimensions of the blowout disc which would best duplicate the early stages of the pressure history at the breech of a standard 5"/38 gun. Pressure-time curves from the 5"/38 gun, firing 15.53 lbs of NPFB-234 powder with the XCM-11 primers, were used as a standard, and the same charge was fired in the Blowout Gun in this series. The two possible variations in the disc dimensions were in disc diameter and disc thickness. A brief description of the results obtained with various discs follows:

a. 4".5 Disc:

A number of rounds were fired in which the discs were 4".5 in diameter with thickness varying from 0".050 to 0".150 in increments of ".025. Maximum breech pressures increased correspondingly from 11,000 psi to 13,000 psi. A pressure "step" of 10,000 psi appeared in all of these rounds. This "step" was very similar to the one appearing in the 5"/38 standard gun firing mentioned above. However, indications were that better duplication could be obtained with a disc of smaller diameter.

b. 3".5 Disc:

Several rounds were fired using discs 3".5 in diameter and 0".050 and 0".075 in thickness. Maximum breech pressures were approximately 22,000 psi with both of these discs. Three distinct pressure "steps" appeared on the breech pressure trace. Each of these "steps" occurred in the same time relationship as the "steps" observed in the 5"/38 standard gun firing mentioned above, the first "step" in the breech pressure of the Blowout Gun being almost identical to that of the standard gun.

c. 3".0 Disc:

Two rounds were fired in which the disc was 3".0 in diameter and 0".050 in thickness. The maximum breech prressure was 36,000 psi. Only one pressure "step" appeared in the initial region of the breech pressure history.

d. 3".5 Vent Hole:

A study of the results obtained from the above discs indicated that the 3".5 diameter disc was best for the objectives of this test. However, it was noted that disc thickness did not affect the pressure curves appreciably and thus it was decided to fire a few

rounds in which a 3".5 diameter vent hole was used in place of the disc. The pressure curves from these firings were very similar to pressure curves from firings in which 3".5 diameter and 0".050 thick discs were used. Appendix (C), Figure 8 contains breech pressure-time curves showing the similarity between the results obtained from using a 3".5 x ".050 disc and a 3".5 vent hole.

The second phase of the tests were conducted to investigate the degree to which pressure-time histories of actual gun firings could be simulated in the Blowout Gun. In connection with a primer research and development project conducted at the Naval Proving Ground in the 5"/38 Gun, a series of breech pressure curves varying from "smooth" to "very rough" had been obtained with NPFB-234 powder by varying only the type of primer. These curves were published in reference (e). Five experimental primers were selected from this group and two rounds using each primer were fired in the Blowout Gun. Reproductions of the pressure-time oscillograms obtained from those firings are contained in Appendix (B), Figures 1 through 5. The primers selected (their designations and characteristics are given in Appendix (A), Table I) had given "smooth" to "very rough" pressure curves in the 5"/38 Gun.

A 3".5 diameter vent was used in all of these firings. The degrees to which actual gun firings were simulated will be seen by examining Figures 9 through 13 of Appendix (C). In these figures, breech pressure curves from the gun and the Blowout Gun are combined on a single plot for each type of primer.

9. RESULTS AND DISCUSSIONS:

a. Blowout Gun:

The first series of firings in this test demonstrated that pressure waves could be produced in the blowout gun. It was further found that the wave configuration was determined more by the blowout disc diameter than by its thickness, and that comparable results were obtained without a disc by varying the vent diameter. This latter method saves considerable time and effort in firing the gun by eliminating the need to replace the disc after each round.

b. Pressure Curves:

The firings of the second phase confirmed the results given above for the first phase and indicated that the wave configuration of actual gun firings could be simulated in the blowout gun over a wide range from "smooth" to "very rough" pressure curves. In comparing the pressure curves from the Blowout Gun and the 5"/38 Gun (Figures 9 through 13, Appendix (C)), it is noted that:

(1) The first pressure "steps" in both guns agree with one another very closely in both magnitude of pressure and time of occurrence.

(2) The three major pressure steps in both guns occur in phase with each other when both curves are plotted from the same reference point (the start of rise of breech pressure was used as the time of reference) and have the same pattern.

(3) The oscillograms from the gages located at 3", 14" and 25" from the breech of the Blowout Gun show that the pressure "steps" are least pronounced at the 14" position (see photographs in Appendix (B), Figure 1 to Figure 5). These records have not been converted to pressure but are all presented with their respective calibrations. The pressure gages have been changed from location to location at times during the program, obviating the possibility of performance peculiar to one gage. The pressure "steps" recorded at the 25" position are displaced in time from those recorded at the 3" position, suggesting travel of the "steps" as a wave, or waves, between breech and muzzle of the Blowout Gun. The low amplitude of the "steps" at the 14" position relative to those at the 3" and 25" position may be the result of the phenomenom of the doubling of the pressure of a traveling wave at reflecting surfaces. At this writing no attempt has been made to analyze these waves or "steps".

c. Ignition Studies:

By considering the relative times at which pressures were first recorded at the three gage positions along the chamber, it was determined that burning of the propellant began in the region of the first two vent holes in the primer for all but one of the primers used in this test. This is in agreement with high speed movies of primer venting. Appendix (B), Figure 6 contains photographs showing the venting of an XCM-11 primer.

The one exception was the XCDB 24/500 primer. Using this primer the pressure records indicated that burning of the propellant began just forward of the end of the extension tube. Photographs of this primer also showed venting occurring at the end of the tube coincident with that at the vent holes, but with a greater volume of gas issuing from the end than through the holes. Appendix (B), Figure 7, contains photographs showing the venting of this primer. The extension tube of this primer is 18" in length with 15" of unvented length.

The velocity of the burning front for the primers used in these tests ranged from 900 f/s to 1300 f/s as measured over a distance of 11" between two chamber gage positions. Also, the velocity of the burning front is directly proportional to the weight of the black powder used in the primer tubes.

PART D

CONCLUSIONS

10. On the basis of the results reported here, it is concluded that:

a. Pressure waves can be produced in the Blowout Gun. The wave configuration depends on the size of the vent hole in the gun and on the type of the primer used.

b. The wave configuration obtained in a 5"/38 Caliber Gun can be duplicated closely in the Blowout Gun over a wide range from "smooth" to "very rough" pressure curves.

c. Burning of the propellant was determined from the pressure-time curves to begin in the region of the first two vent holes in the primer.

d. For the series of primers used on these tests, the pressure waves become more pronounced as the point of ignition moved forward in the charge (as the length of the unvented portion of the primer is increased).

e. The velocity of the burning front in the charge is directly proportional to the weight of the black powder used in the primer tube and varied from 900 f/s to 1300 f/s for the primers used in this test.

Ballistic Tests in the 5"/38 Caliber Blowout Gun

The tests upon which this report is based were conducted by:
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J. NANIGIAN, Physicist, Interior Ballistics Division, Armament Department

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Commander, Naval Proving Ground

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Captain, USN
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Encl: (1) Breech Pressure Curves from 5"/38 Gun and 5"/38 Blowout Gun, Figure 10, Appendix C

1. It is requested that Figure 10, Appendix C in subject report be destroyed and replaced by enclosure (1).

2. This letter may be downgraded to "Unclassified" upon removal of enclosure (1).

J. F. BYRNE

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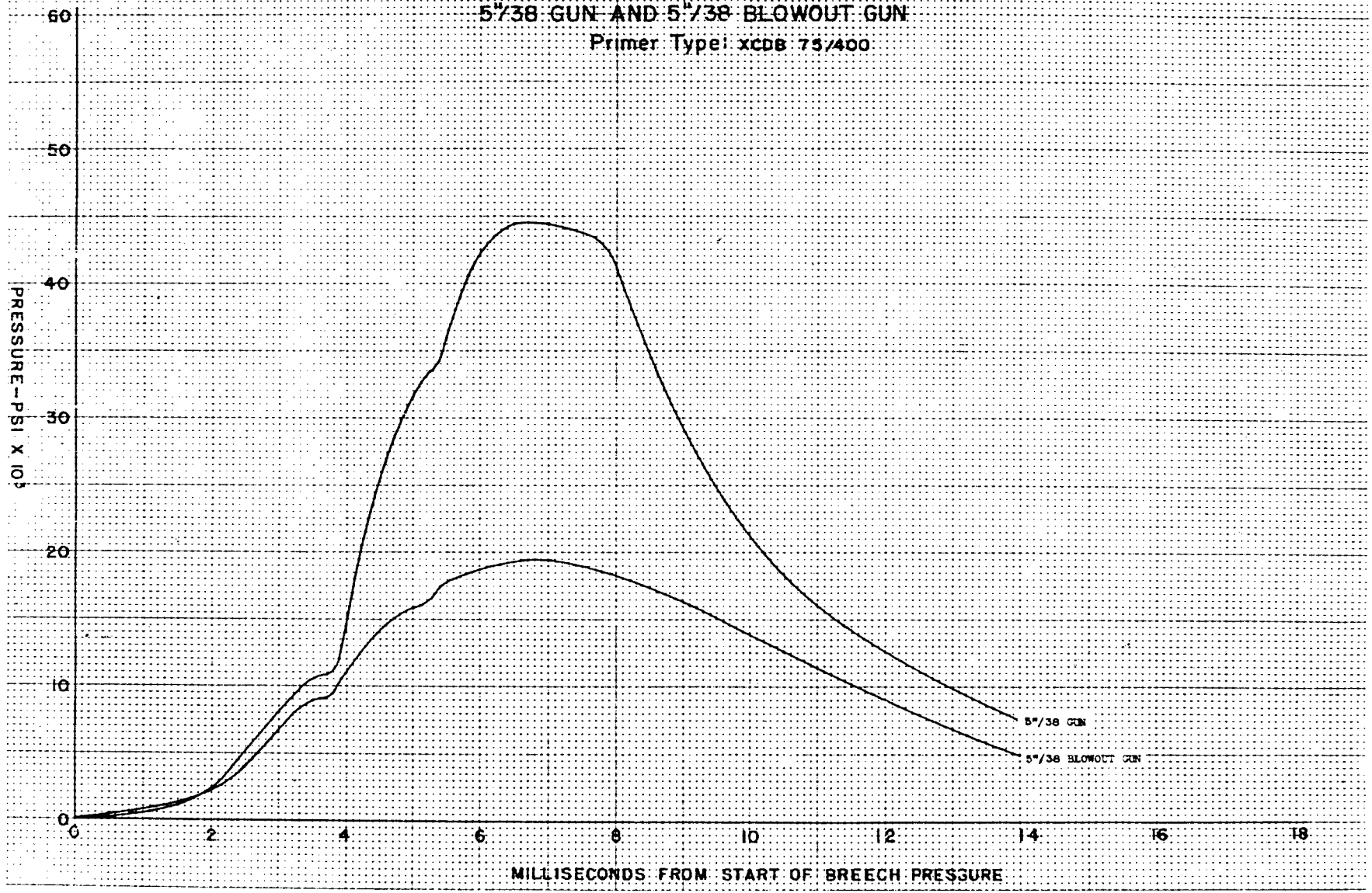
BREECH PRESSURE CURVES
From
5"/38 GUN AND 5"/38 BLOWOUT GUN
Primer Type: xCDB 75/400



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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Second Partial Report

on

Ballistic Tests in the 5"/38 Caliber Blowout Gun

- -

The Production of Pressure Waves in the 5"/38 Caliber Blowout Gun

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Date: SEP 30 1953

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5"/38 CALIBER BLOWOUT GUN

Pressure-Time Oscillograms
Primer: XCM11

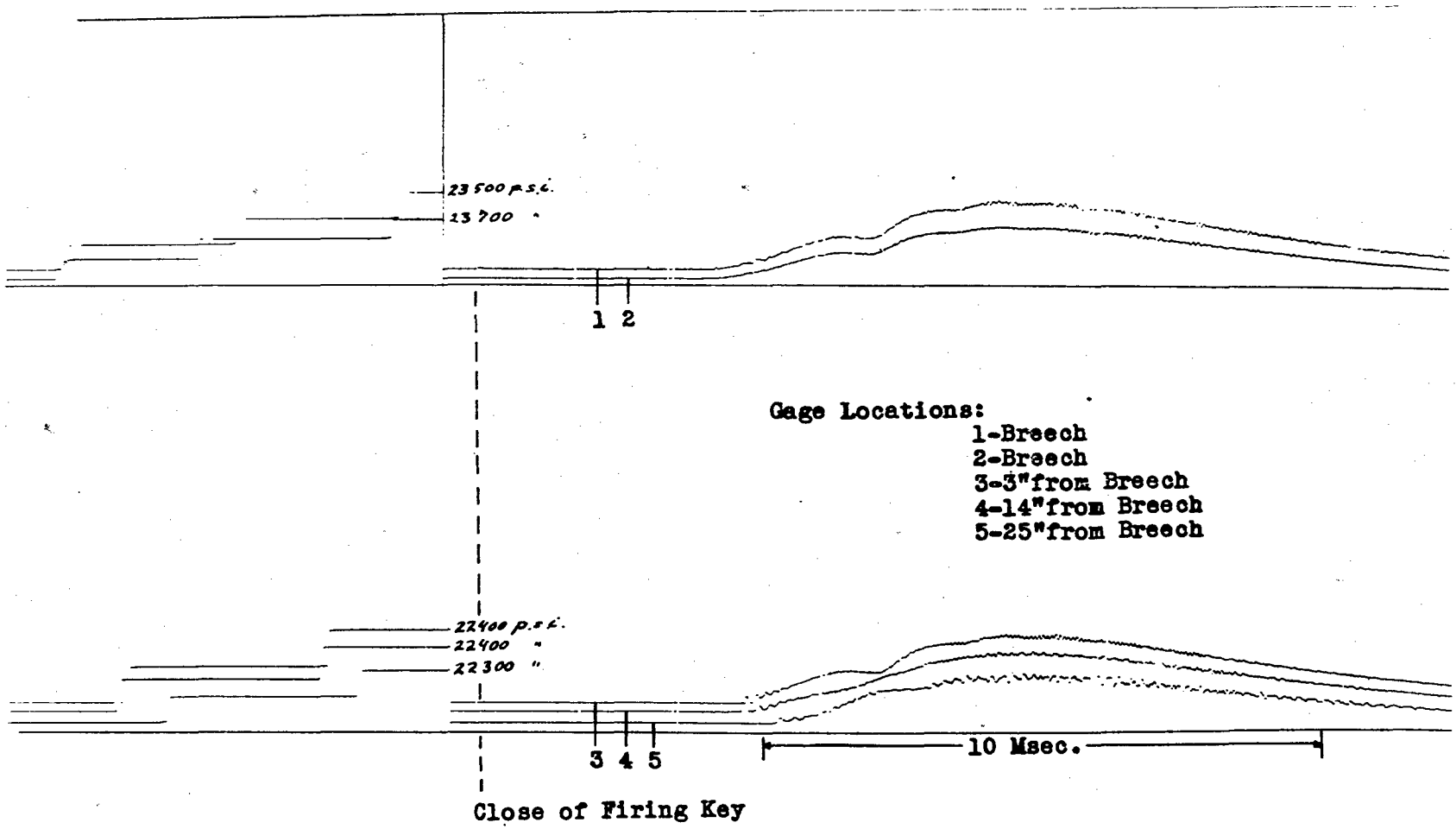

Figure 1 Appendix B

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5"/38 CALIBER BLOW-OUT GUN

PRESSURE -TIME OSCILLOGRAMS
Primer: XCDB 75/400

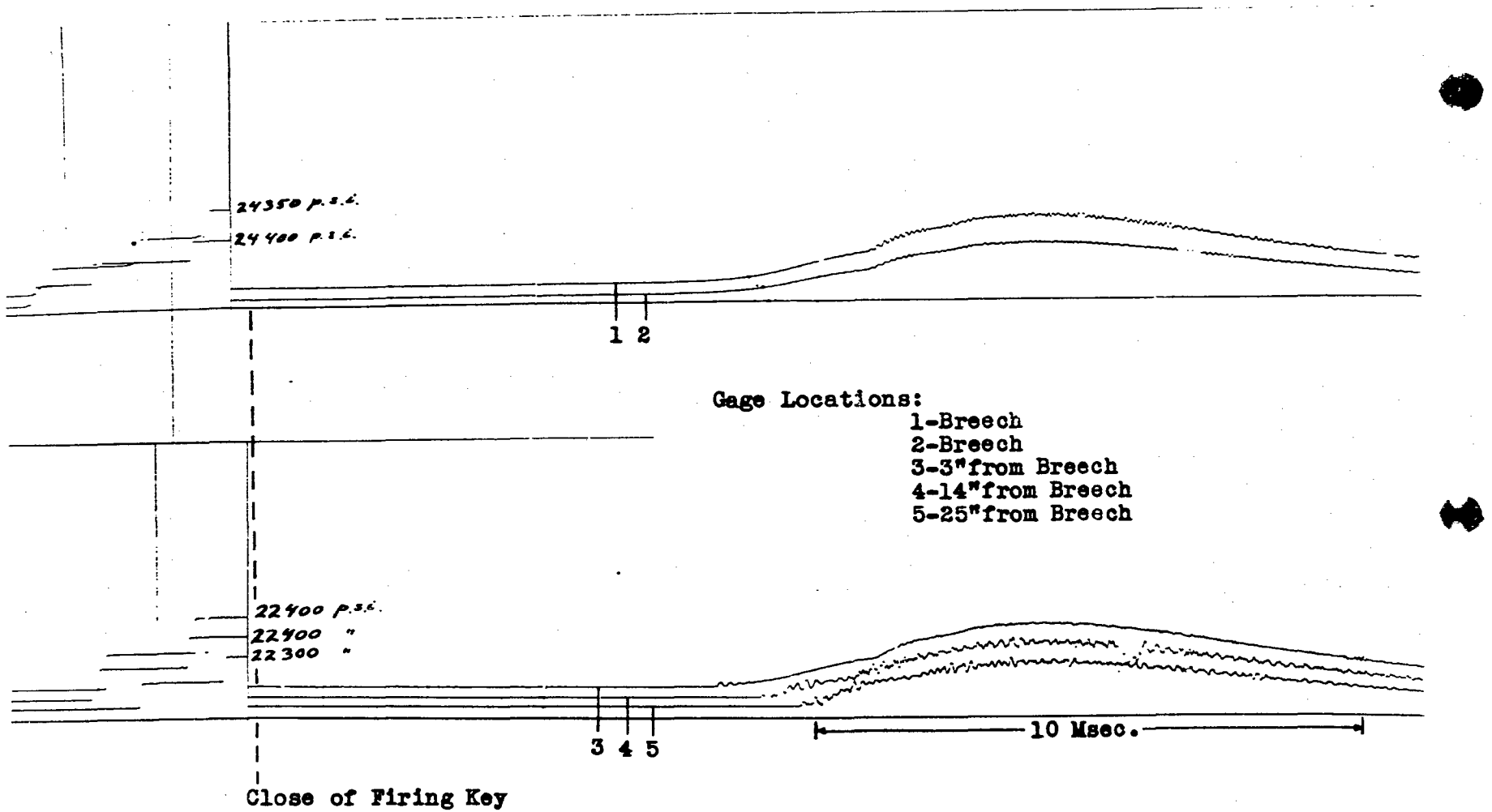

Figure 2

Appendix D

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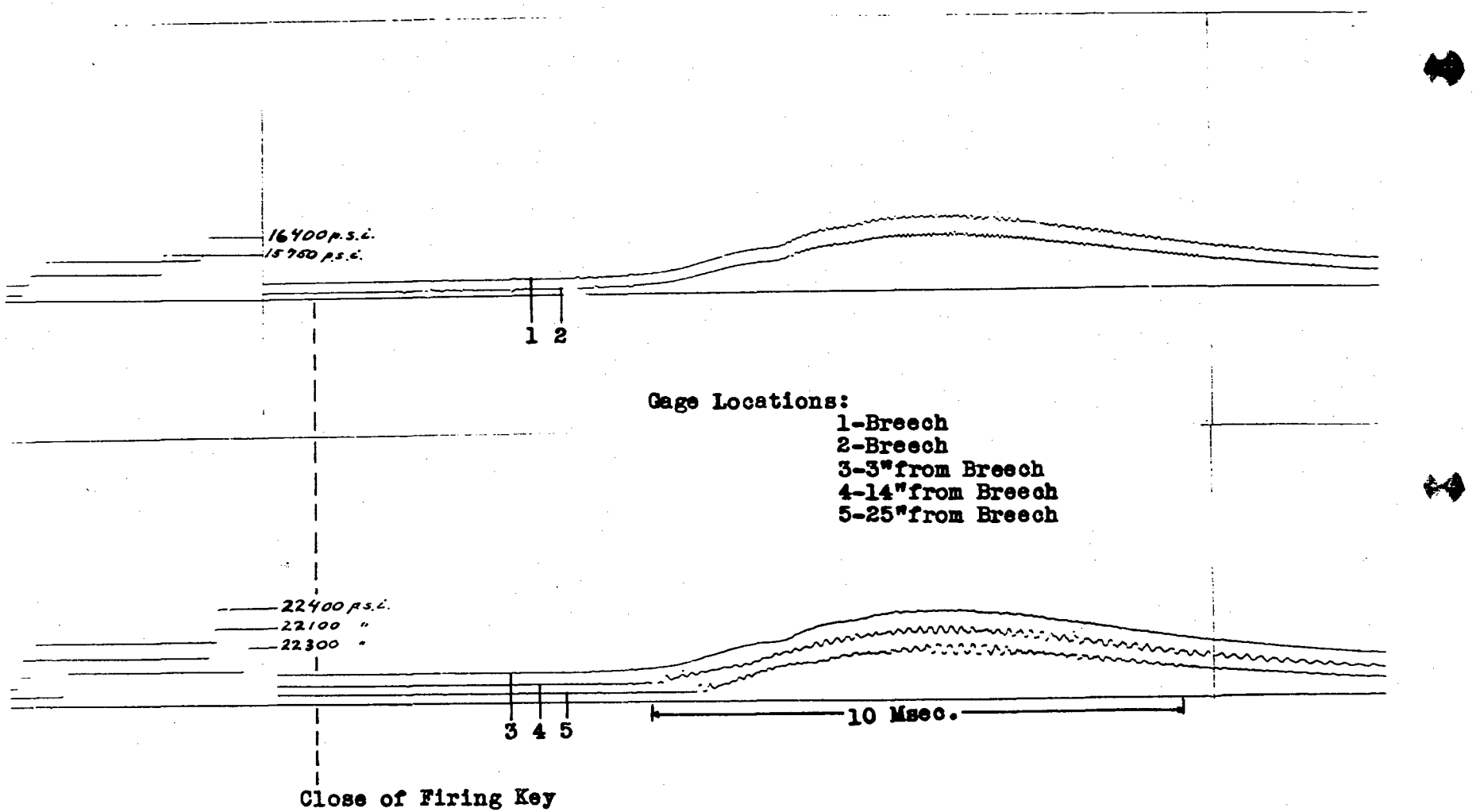
5"/38 CALIBER BLOW-OUT GUN

PRESSURE-TIME OSCILLOGRAMS
Primer: XCDB 15/300

Figure 3

Appendix B



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5"/38 CALIBER BLOW-OUT GUN

PRESSURE-TIME OSCILLOGRAMS
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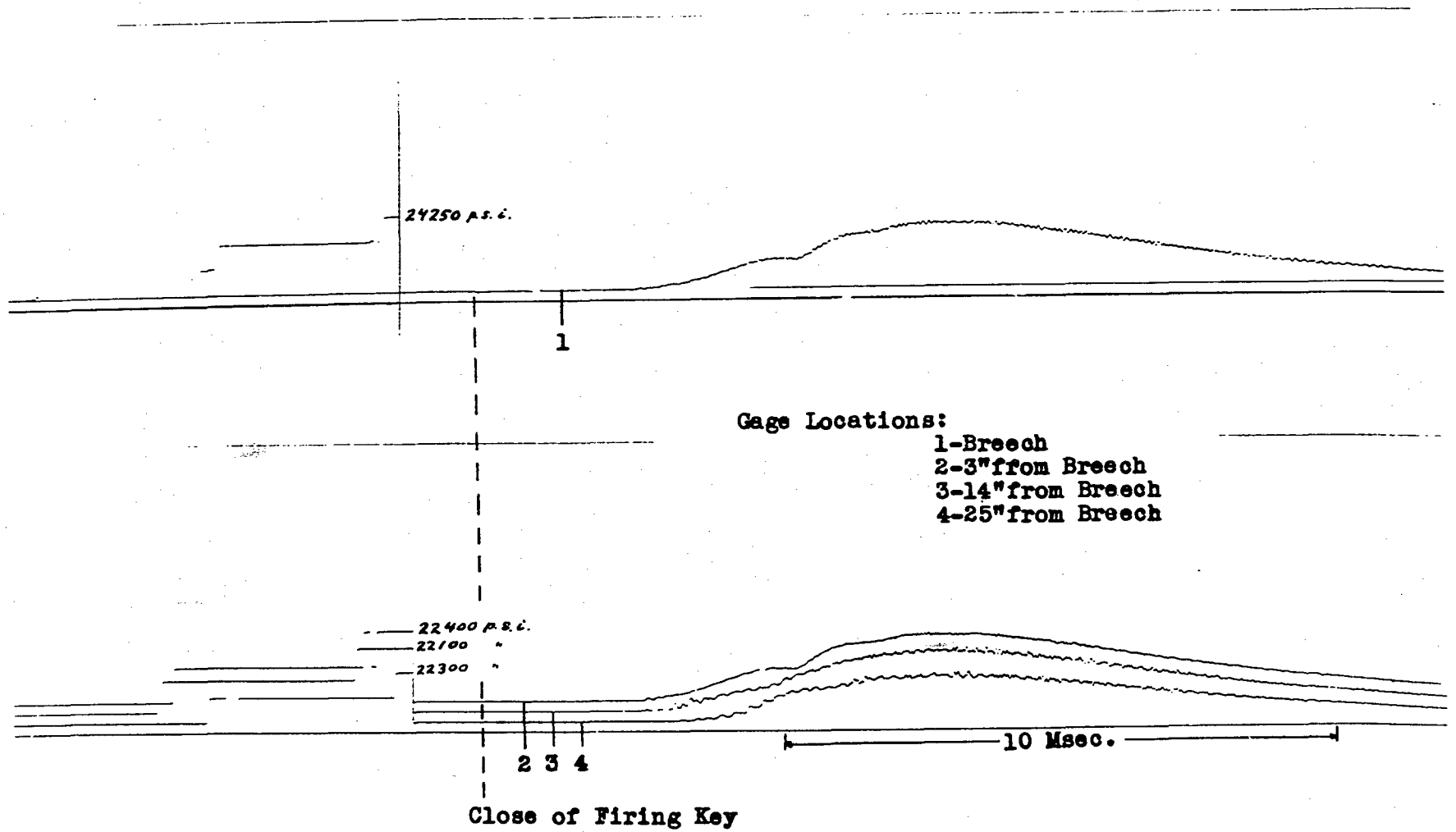

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5"/38 CALIBER BLOW-OUT GUN

PRESSURE-TIME OSCILLOGRAMS
Primer: XCDB 24/500

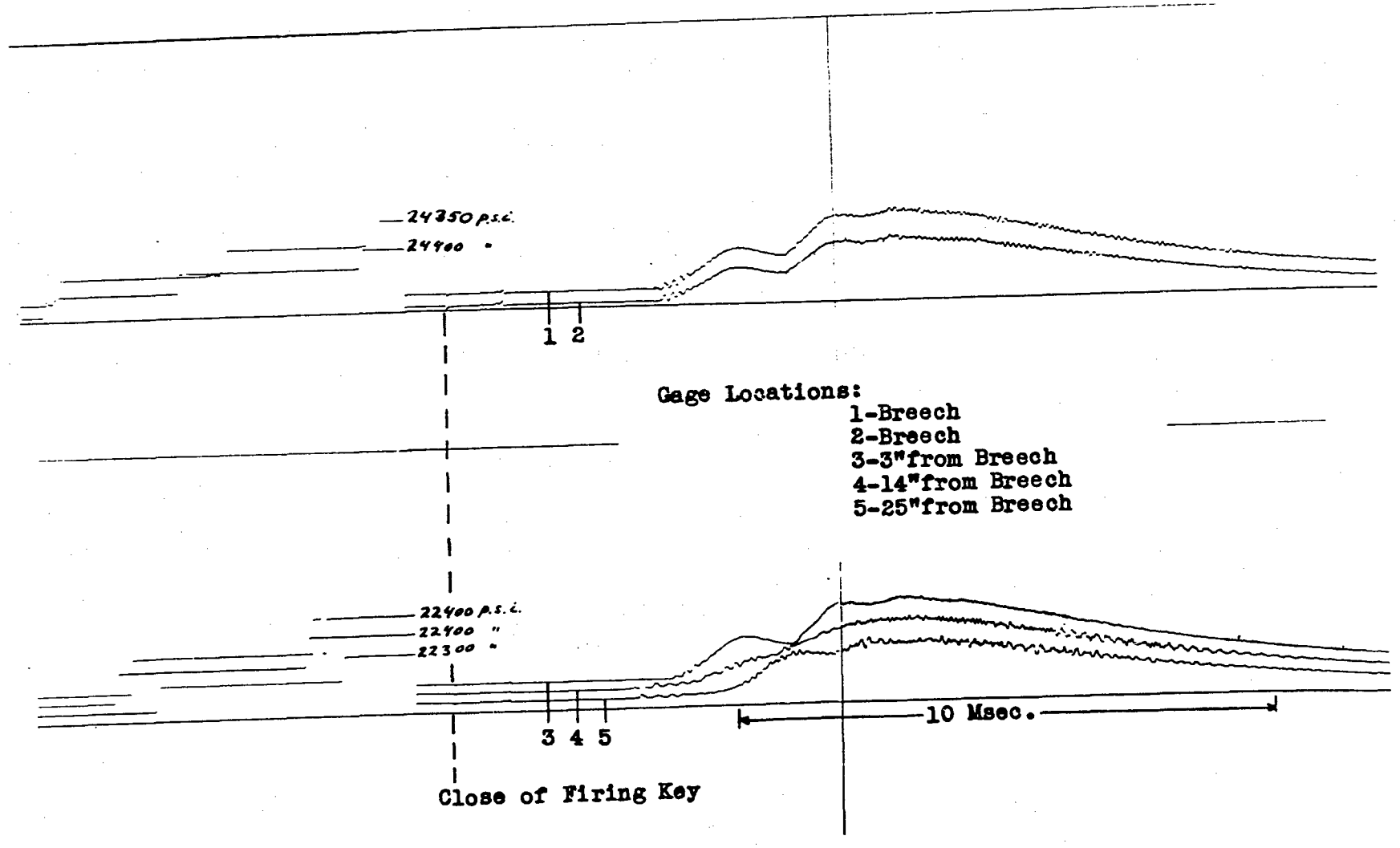

Figure 5 appending X3

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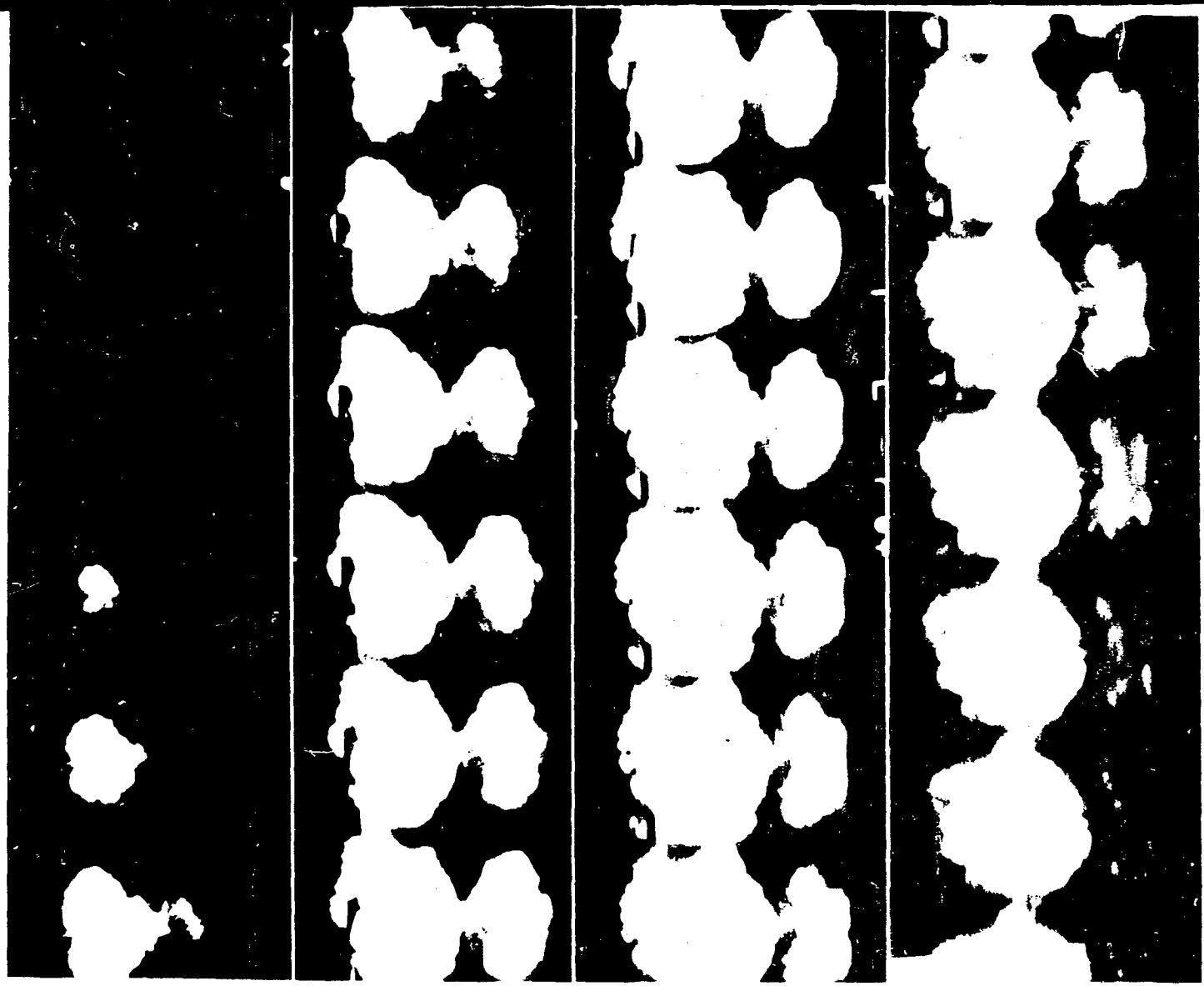
High Speed Photographs of the Venting
of Type XCM-11 Primer
Recording Rate - 6000 f.p.s.



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High Speed Photographs of the Venting
of Type XCDB 24/100 Primer
Recording Rate - 6000 f.p.s.

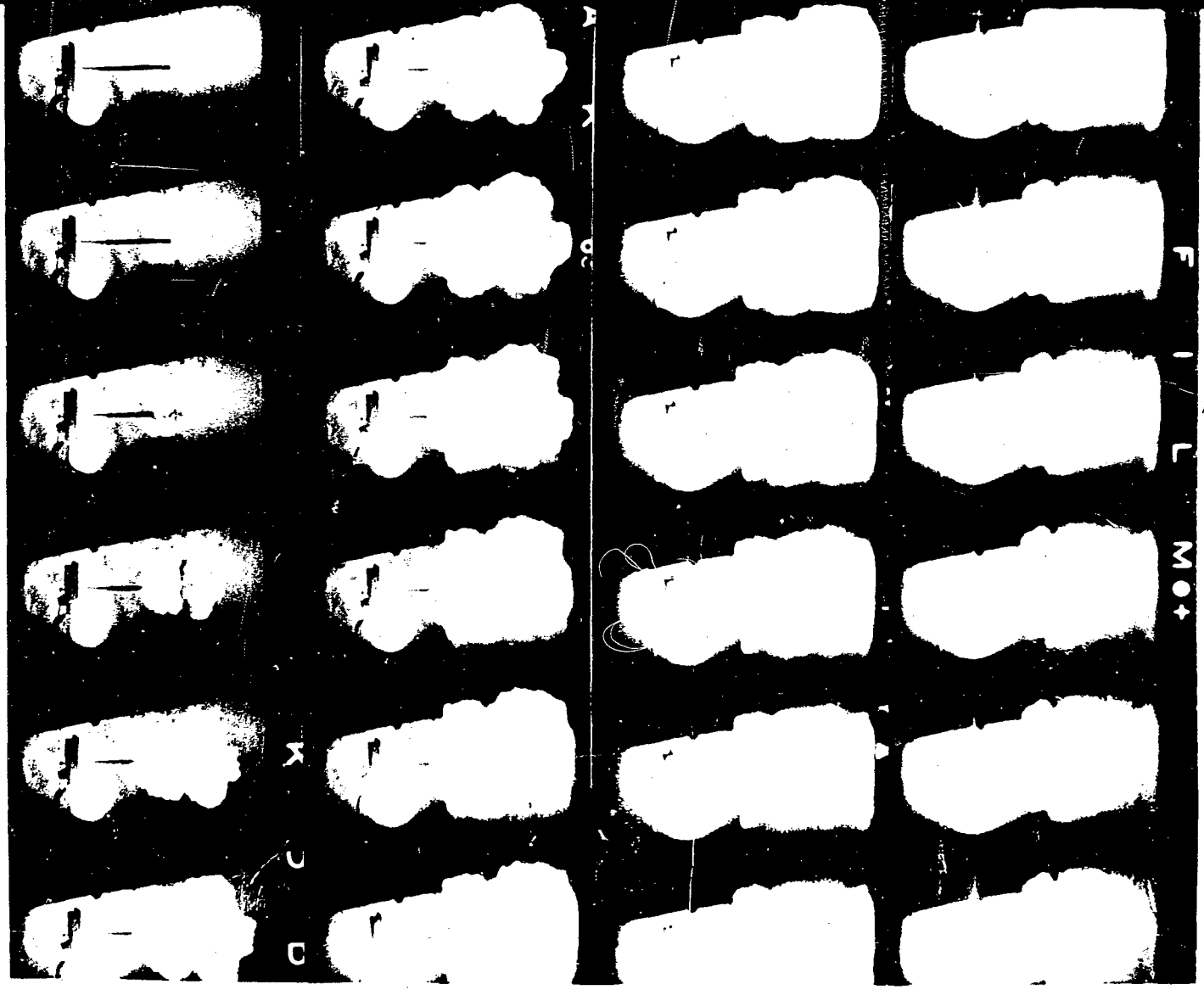

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Fig 7

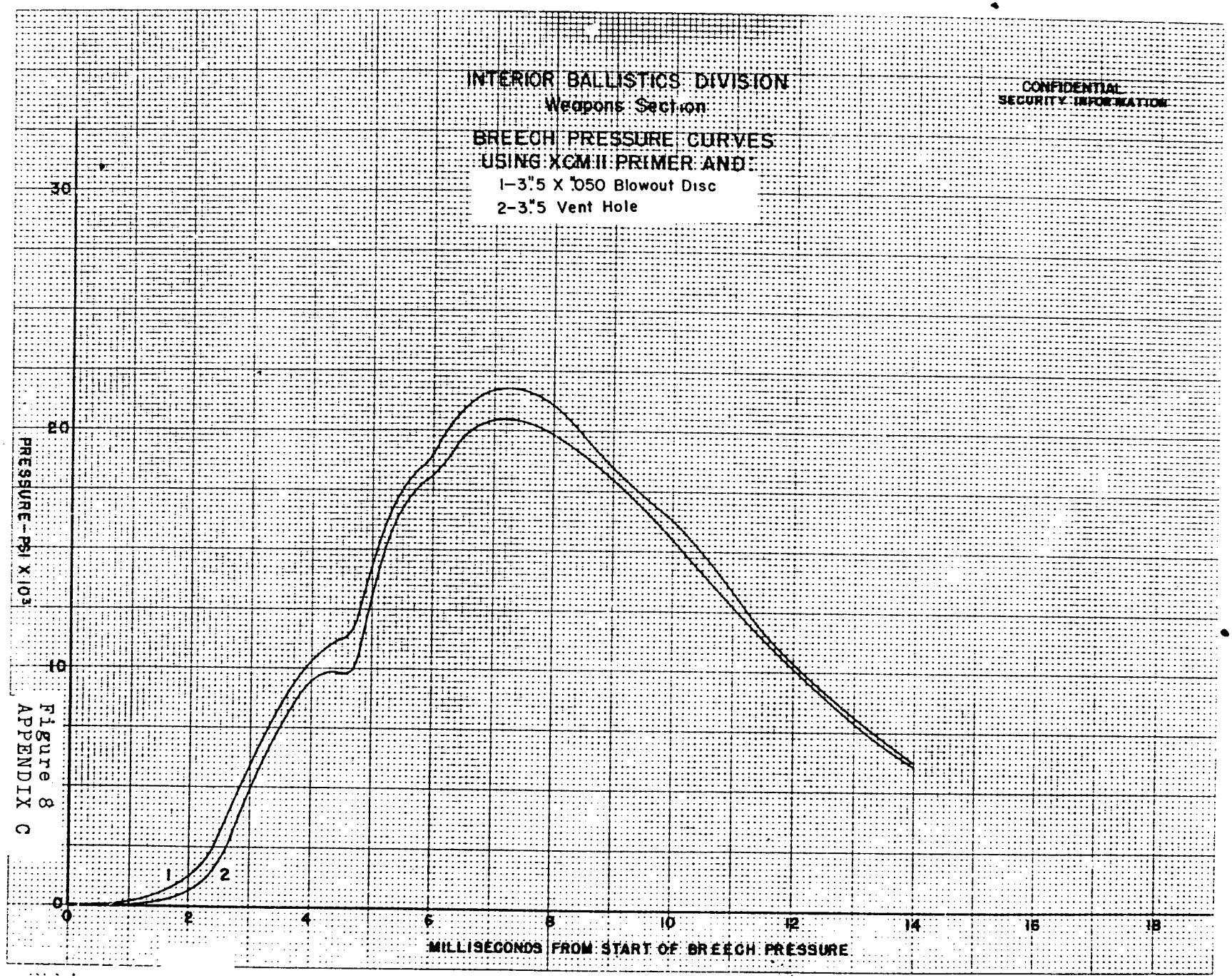

Figure 8
APPENDIX C

[redacted]

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BREECH PRESSURE CURVES
From
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Primer Type XCM II

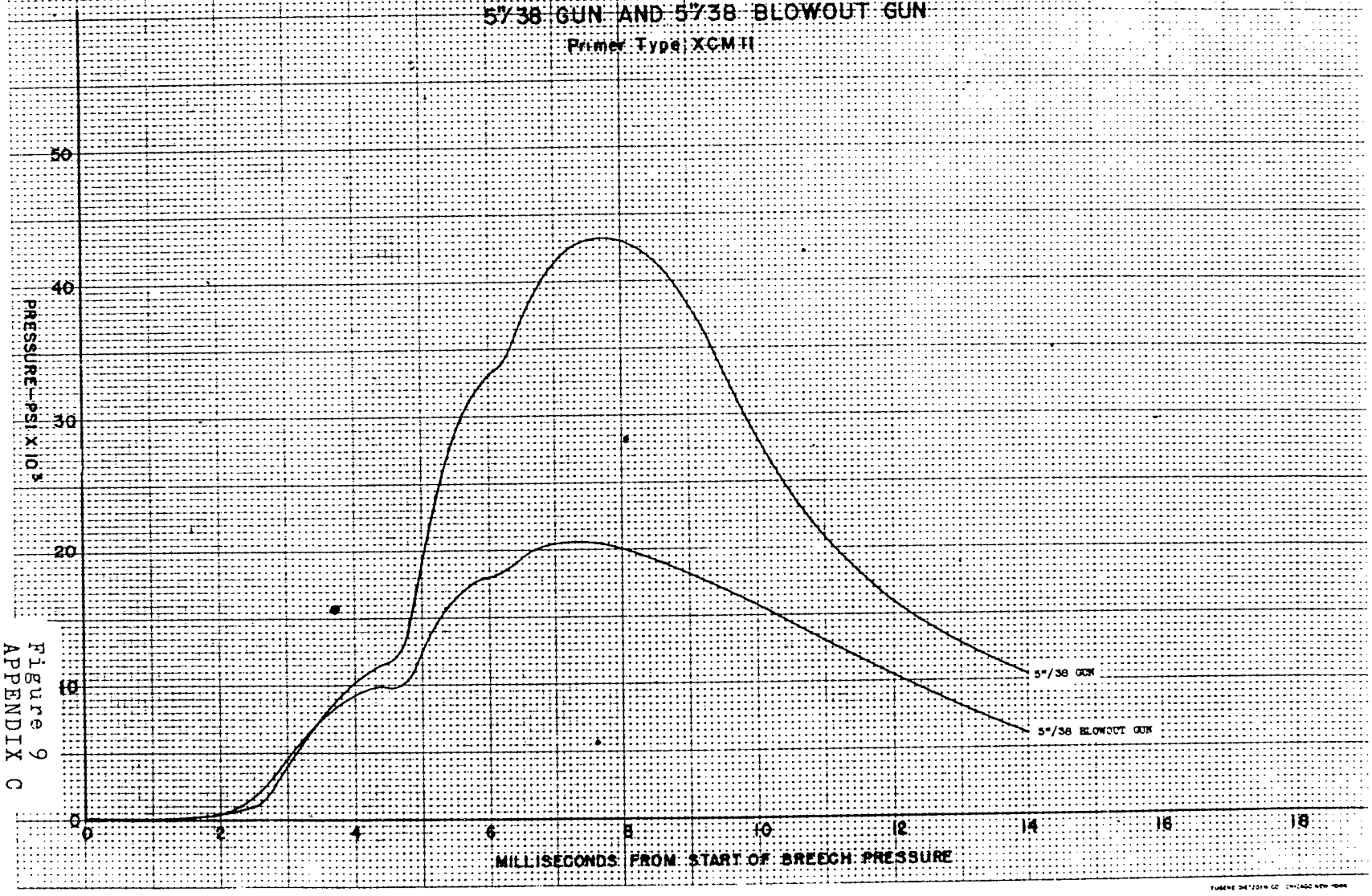

Figure 9
APPENDIX C

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BREECH PRESSURE CURVES
From
5"/38 GUN AND 5"/38 BLOWOUT GUN
Primer Type: XCDB 75/400

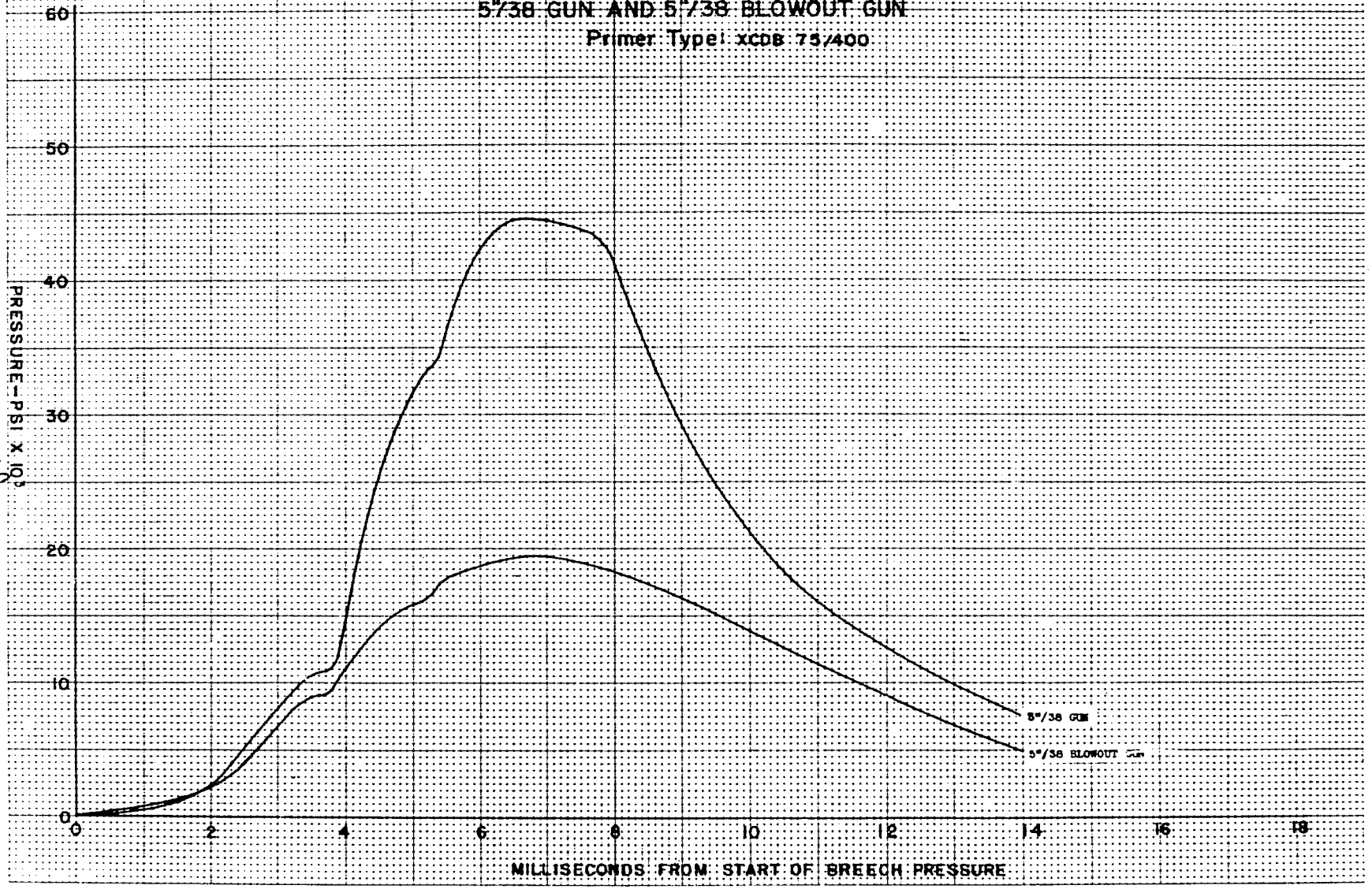

Figure 10 (continued)

Appendix C

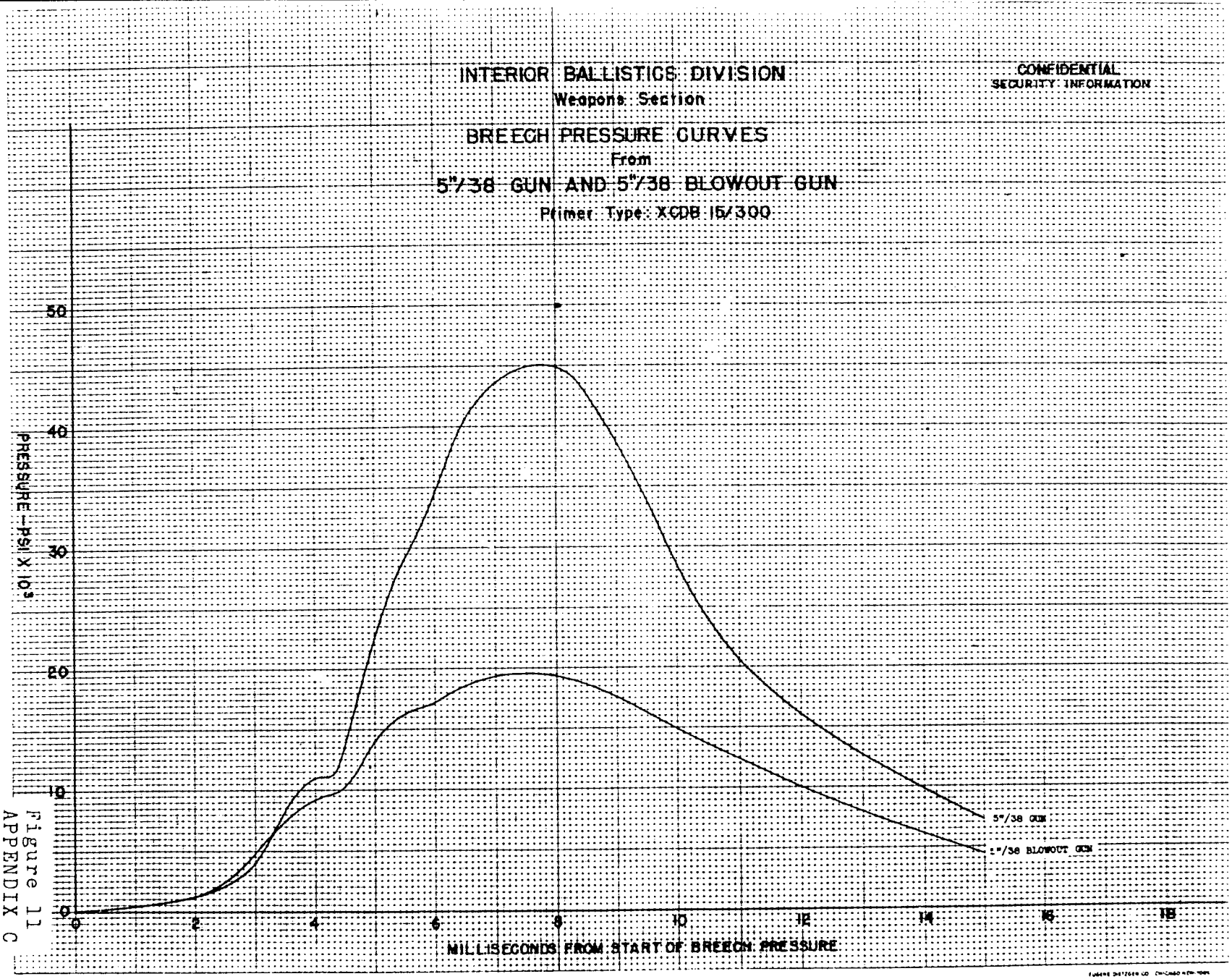

Figure 11
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BREECH PRESSURE CURVES
From
5"/38 GUN AND 5"/38 BLOWOUT GUN
Primer Type: XCDB 30/400

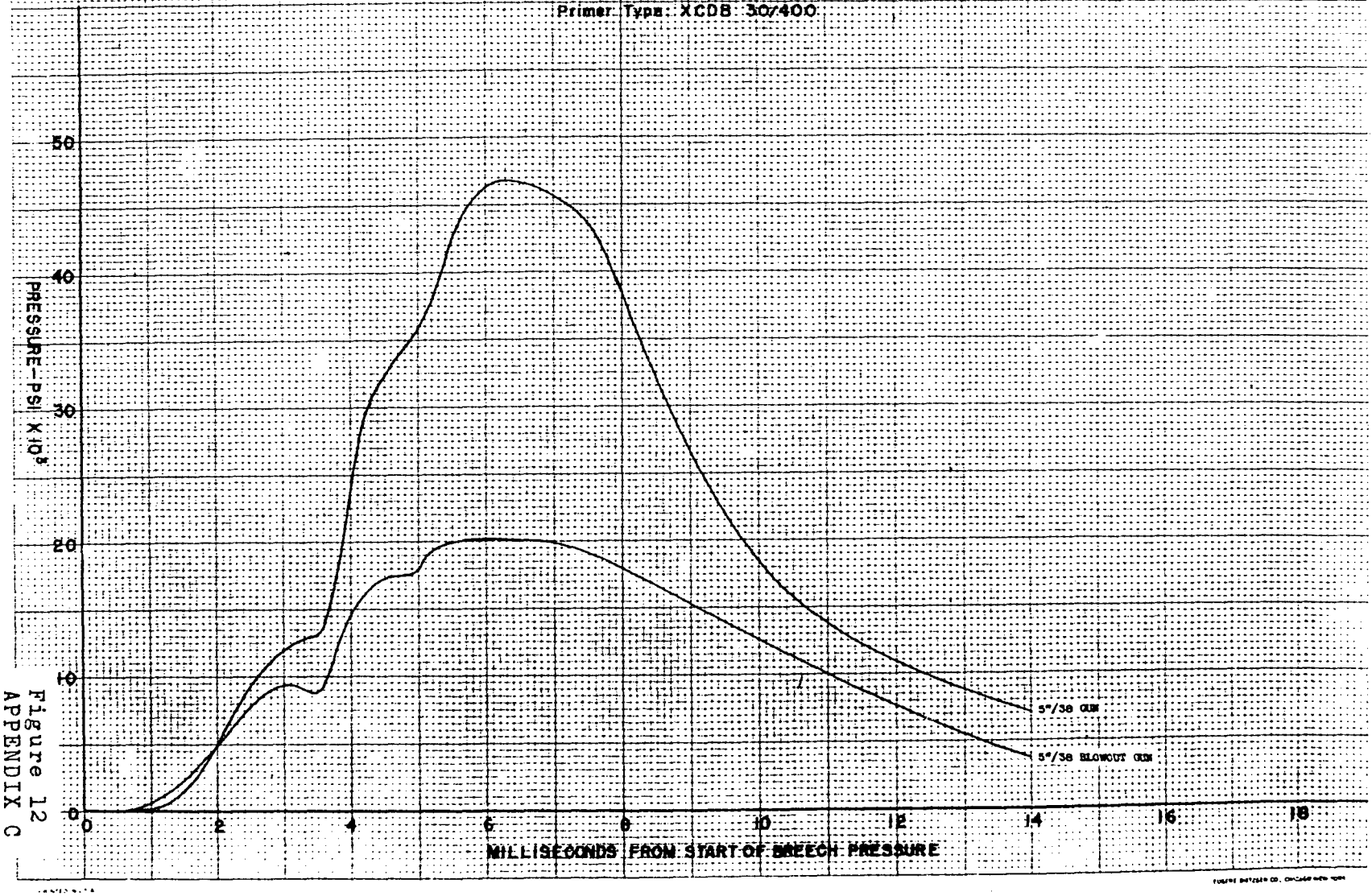

Figure 12
APPENDIX C

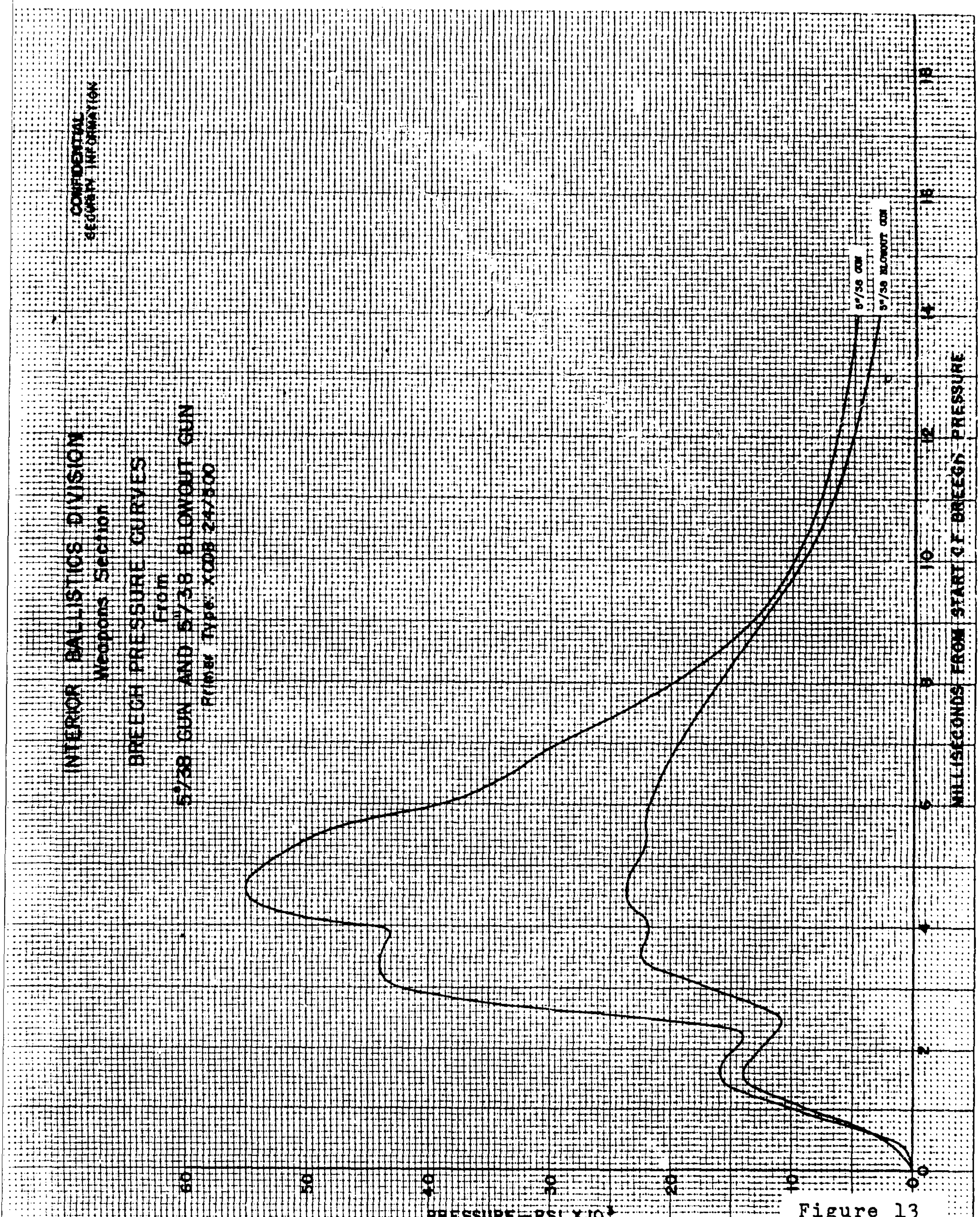

Figure 13
APPENDIX C

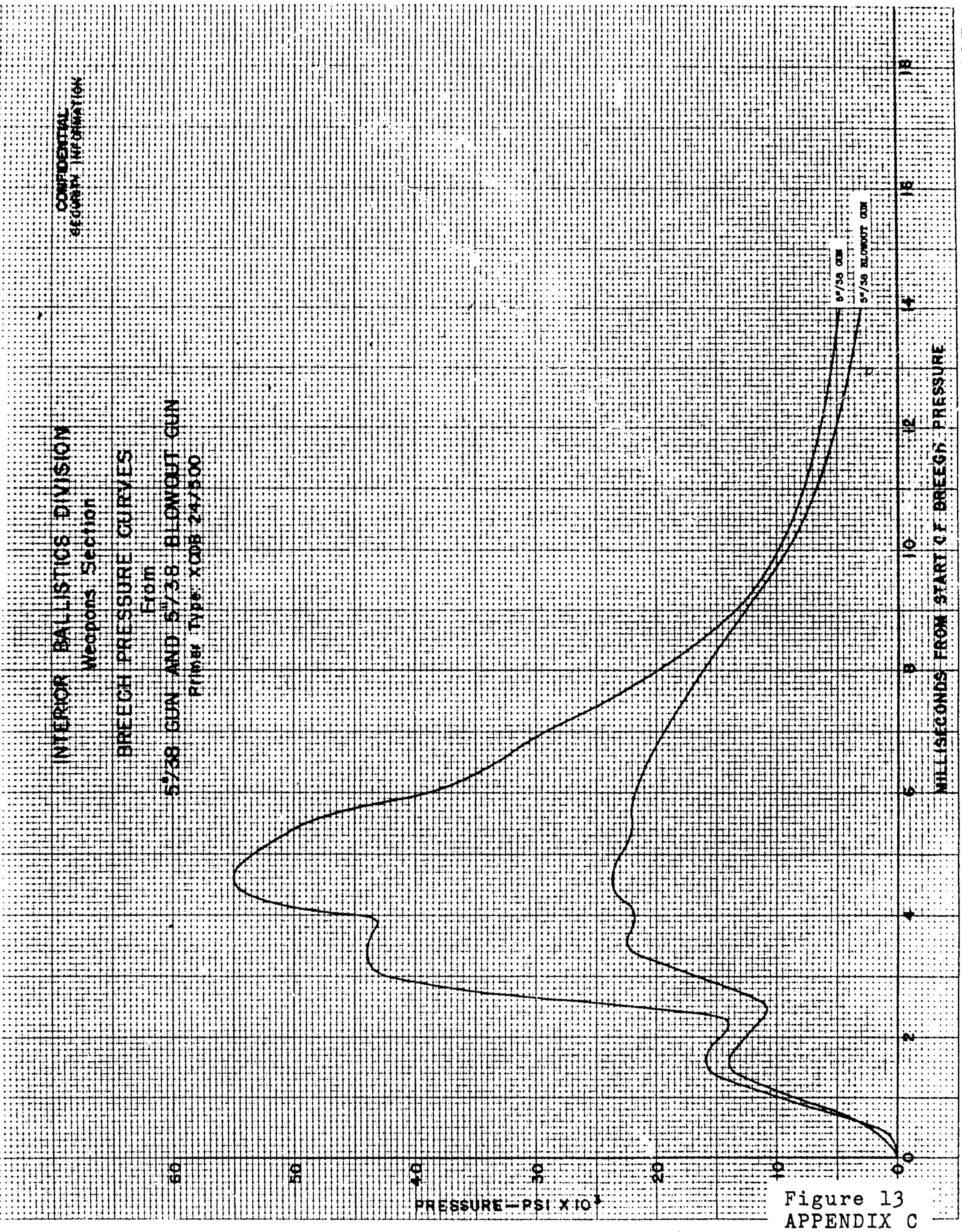

Figure 13
APPENDIX C